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EVOLUTIONARY TECHNOLOGY IN THE CURRENT REVOLUTION IN MILITARY AFFAIRS:

The Army Tactical Command and Control System

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STRATEGIC STUDIES INSTITUTE

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FOREWORD

In this monograph, Ms. Elizabeth A. Stanley analyzes developments in the Army Tactical Command and Control System as a vehicle for assessing the U.S. Army's strategy for exploiting information age technologies. Her analysis will be of great value to those interested in several dimensions of military modernization, in particular whether we are amid a revolution in military affairs (RMA) or something less profound. If it is an RMA, then how well are we in the Army seizing the opportunities it presents?

Ms. Stanley takes the reader through the evolution of the Army's efforts to harness the microchip to its command and control system. While the account is interesting in its own right, the lessons she derives from it have the greatest value to us today as we consider the next chapter in the Army's development.

Ms. Stanley sees Force XXI more as the latest phase in a decades-long process than a new beginning. She points out, for instance, that despite the Force XXI initiatives inspired by former Army Chief of Staff Gordon R. Sullivan, which seem to be coming to fruition, the Army has not altered its core tasks nor displaced any of its combat platforms. Changes largely have been marginal, revolving around the leveraging of technologies into existing systems.

The deeper message here is that technological change, evolutionary and revolutionary, does not just happen. It requires the vision of leadership, corporate acceptance, and managerial genius to guide it to effective implementation. The strength of the Army is that it has become the world's finest land force by openly discussing not only its vision for the future, but also the processes by which it has gotten to where it is today and where it intends to be tomorrow. Therefore, I commend to you Ms. Stanley's paper precisely because she has taken a somewhat cautionary view of the path along which the Army is proceeding.

Ms. Stanley, a former Army captain and currently a doctoral candidate in the Department of Government at Harvard University, originally wrote this paper as part of a grant provided by the National Science Foundation. Subsequently, Women In International Security (WIIS) conveyed their Best Paper of 1997 Award on Ms. Stanley at WIIS's Annual Summer Symposium for Graduate Students in International Affairs.

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ELIZABETH A. STANLEY is a doctoral candidate in the Department of Government at Harvard University. Before starting this degree, she served as a military intelligence officer in the U.S. Army in Korea, Germany, Italy and Bosnia. Among other assignments, she participated in the 1st Armored Division's fielding of the All Source Analysis System (ASAS). Ms. Stanley holds a BA in Soviet and East European Studies from Yale University. She recently published a chapter on Russian security policy in *Korea—Security Pivot in Northeast Asia* (Washington, DC: Hudson Institute, 1997) and will soon publish a study for the Congressional Budget Office on the impact of peace operations on the U.S. military.

EVOLUTIONARY TECHNOLOGY IN THE CURRENT REVOLUTION IN MILITARY AFFAIRS: THE ARMY TACTICAL COMMAND AND CONTROL SYSTEM

> I see . . . an integrated area control system that exploits the advanced technology of communications, sensors, fire direction and automatic data processing. . . . Enemy forces will be located, tracked, and targeted almost instantaneously through use of data links, computer assisted intelligence evaluation and automated fire control. . . . With cooperative effort, no more than ten years should separate us from the automated battlefield.[1]

It's a grand blueprint for a revolutionary concept of land warfare. Visionary. Dynamic. And it's almost here—only 20 years late. In 1969 then Chief of Staff of the Army General William C. Westmoreland described this vision of an automated battlefield at a meeting of the Association of the United States Army. Thirty years and billions of dollars later, the U.S. Army is still waiting for his dream to become reality. The saga of the Army's efforts to automate tactical command and control spans decades and serves as a fascinating case study for a theoretical inquiry about innovation in military organizations. Moreover, the Army Tactical Command and Control System—or ATCCS, as this automated system became known—can provide some useful insights into the contemporary Revolution in Military Affairs (RMA), whose status continues to be debated by scholars and soldiers alike. I argue that although ATCCS had the potential to be a revolutionary innovation, various aspects of its development process and the Army's procurement process have caused it to miss its mark.

ATCCS was designed to become the principal command and control focus within a theater of military operations. The plan envisioned respective control systems for the five battlefield functional areas (BFAs)—maneuver, fire

support, air defense artillery, intelligence/electronic warfare, and combat service support—and three primary communications systems. Through the use of common hardware and software, each BFA was to manage, coordinate and process information internally. Force Level Control was to provide the mechanism for the commander and staff to coordinate horizontally among the BFAs at each level, as well as for the BFAs to coordinate vertically among echelons.

This paper is divided into seven sections. The first section outlines the theoretical considerations for innovation in military organizations, while the second section explains the concept of the current RMA in greater detail. The third section recounts the first three generations in the family of automated command and control (C^2) systems which eventually became known as ATCCS. In the fourth section, I argue that the development of this intellectual vision culminated with the fourth generation, a system called Sigma Star. The fifth section outlines the development of ATCCS until the Gulf War. Some of the ATCCS systems were deployed in DESERT STORM with mixed results, as the sixth section will show. After the performance in DESERT STORM, a heightened interest in battlefield situational awareness catalyzed a top-down Army reorganization effort, led by then-Chief of Staff of the Army General Gordon Sullivan. The first half of the sixth section describes Sullivan's vision of Force XXI and its implications for ATCCS. Although Force XXI involved a serious image overhaul of the Army's battlefield digitization, the successor to ATCCS—called the Army Battle Command System (ABCS)—added little value to the previous Sigma Star paradigm. The Army tested ABCS in March 1997 in a brigade-level Advanced Warfighting Experiment at the National Training Center; the second half of the sixth section describes some preliminary results—from the perspective of several participants—of this experiment. The final section analyzes ATCCS in light

of innovation theory and draws some implications for the current RMA.

Theoretical Considerations.

Before deciding whether ATCCS is a component of the current RMA, or even if it is a military innovation in general, it is necessary to define these terms. In the theoretical literature about military innovation, authors' viewpoints diverge in two areas: the definition itself—what is military innovation?—and its underlying causal forces—what causes military innovation? This section will briefly review the relevant literature and offer working definitions of "military innovation" and RMA; the major hypotheses from this literature will then become the standards against which ATCCS will be compared.

Most authors differentiate between types of innovation—peacetime versus wartime, technological versus doctrinal, evolutionary versus revolutionary. To simplify the process, it makes sense to focus around Wilson's elegant definition that "real innovations are those that alter core tasks."[2] This definition is echoed by Rosen and Cote, who focus somewhat more carefully on the parts of the organization performing the tasks. According to Rosen, a major military innovation is defined as:

> a change in one of the primary combat arms of a service in the way that it fights or alternatively, as the creation of a new combat arm. . . . A major innovation also involves a change in the relation of that combat arm to other combat arms and a downgrading or abandoning of older concepts of operations and possibly of a formerly dominant weapon.[3]

Cote makes the same point by calling innovation a "major change in the division of labor" among the combat arms.[4] Both authors define a combat arm as a "functional division" or "platform community" within a service, oriented around a particular weapon system. Thus, these three definitions of

military innovation share a focus on doctrinal or organizational—rather than technological—change.

For a military innovation also to be labeled a "Revolution in Military Affairs," it must combine a new technology with the doctrinal or operational change of the three definitions above. Most authors agree that an RMA is only possible through the synthesis of technological and doctrinal innovations; Hayes and Gardiner both talk of a "marriage between doctrine and technology."[5] Krepinevich argues that newly emerging technologies can make an RMA possible, but technological innovation alone cannot spark an RMA. "To realize their full potential, these technologies typically must be incorporated within new processes and executed by new organizational structures."[6] In other words, technology is a necessary but not a sufficient condition for an RMA. Or as Cordesman points out, "He who dies with the most toys simply dies, he does not win. Technology will only be valuable to the extent it is integrated into an effective overall force structure."[7]

Libicki and Hazlett use the term "Military-Technical Revolution" (MTR) to clarify this distinction: a military-technical revolution is the impact of a new technology on warfare, while an RMA encompasses the subsequent transformation of operations and organization.[8] Similarly, Fitzsimmons and Van Tolz suggest that there are three preconditions necessary for the full realization of an RMA: technological development, doctrinal innovation, and organizational adaptation.[9] Cooper's list is essentially the same, except that he divides the concept into four components: evolving military systems, emerging technology, operational innovation, and organizational adaptation.[10] Thus—while authors disagree whether doctrinal or technological innovation is causally prior—there is consensus that both components are necessary for an RMA. By differentiating an RMA from an MTR, it places increasing importance on doctrinal and operational innovation and less importance on the technology. As Metz and Kievit note:

> The basic premise of the RMA is clear: throughout history, warfare usually developed in an evolutionary fashion, but occasionally ideas and inventions combined to propel dramatic and decisive change. This not only affected the application of military force, but often altered the geopolitical balance in favor of those who mastered the new form of warfare.[11]

In sum, for the purposes of this paper, a "military innovation" is the doctrinal, operational, or organizational innovation to which Rosen, Cote, and Wilson refer. A "Military-Technical Revolution" describes cases where technology is the predominant factor in innovation, especially when technology is employed in an evolutionary manner, without causing doctrinal or organizational change. In this way, my definition for MTR resembles Cote's definition for "evolution." Finally, a "Revolution in Military Affairs" combines these first two concepts synergistically; technological, doctrinal, and organizational innovation must all be present for an RMA to occur.

With these definitions in mind, it is easy to understand why many scholars argue that military organizations resist innovation. As Rosen points out, large bureaucracies are not only difficult to change, they are explicitly designed not to change—"the absence of innovation is the rule, the natural state."[12] Posen agrees that military innovation is rare for two reasons. First, the process of institutionalization gives most members a stake in the ways things are currently organized. Second, innovation will increase operational uncertainty, the one thing that large organizations hope to minimize.[13] Wilson argues that this resistance to innovation is even stronger in military organizations than in other bureaucracies, because members have a strong sense of mission and face greater penalties for operational uncertainty. Thus he posits that military organizations will accept—or at least not bitterly resist—"innovations that facilitate performance of existing tasks in a way that is consistent with existing managerial arrangements." This bias towards maintaining the existing task definitions can

lead the organization to adopt new technology without understanding its significance.[14]

If military innovation is such a rare occurrence, what causes it? The literature offers numerous explanations—including external threat, civilian intervention, inter- and intra-service rivalry, individuals and war or peace. The five themes are separated here for the sake of clarity, but this artificial division does not minimize the correlation among them.

First, authors diverge on the importance of an external threat as a cause of innovation. The biggest supporter of external threat is perhaps Posen, who argues that when threats rise, the military loses its operational autonomy as civilians intervene to "repair" the organization. Increased threat will increase civilian intervention, but "soldiers tend to be more amenable to external prodding when threat of war looms larger." This is especially likely in "politically isolated or geographically surrounded states" which are more vulnerable.[15] Another supporter is Cote, who asserts that military innovation must occur during high threat and a perception of low resource availability to balance against the threat. In contrast, Rosen places very little importance on external threat in innovation.

The second cause of innovation is civilian intervention. Posen concludes that civilian intervention is most likely during high external threat, after military defeat, or in preparation for national expansionism. The literature is divided into two types of civilian intervention. The first relates to funding constraints—which Cote calls the "domestic political economy of the defense budget." Many authors—including Fitzsimmons and Van Tolz, Cote, and Posen—argue that shrinking budgets will cause civilians to intervene and prioritize defense dollars. Alternatively, the political leaders may cause the services to fight it out among themselves. The second type of civilian intervention, technology transfer, is more subtle. As Krepinevich argues, the technologies that eventually cause military innovations

and RMAs are often originally developed outside of the military and then "imported and exploited for their military applications."[16] This is even more important with the current RMA, because in the 1980s the main arena for technological innovation shifted from the government to the commercial sector.[17]

The third cause, inter- and intra-service rivalry, follows directly from civilian intervention. Hayes argues that inter-service rivalry stimulates innovation, especially in response to Congressional control of the purse strings.[18] In contrast, Rosen focuses more on intra-service ideological struggles over a "new theory of victory." This ideological struggle occurs within different leadership cliques of the same service, as senior leaders try to advance their particular intellectual and operational vision.[19]

Rosen's concept of an ideological struggle relates to the fourth cause of innovation: individuals. As Hayes points out, "people, not organizational arrangements, make the greatest difference to innovation."[20] Although many authors agree that individuals are important in the innovative process, their views diverge about which individuals. Rosen asserts that innovation must come from the top-down influence of senior military leaders, who accept that the nature of conflict is undergoing fundamental change. Then, Rosen argues, if "military leaders . . . attract talented young officers with great potential for promotion to a new way of war, and then . . . protect and promote them, they [can] produce new, usable military capabilities."[21] Wilson seconds the importance of executive leaders in explaining change. He cites a study which found that top executives' beliefs were better predictors of change than any structural features of the organization. However, because "innovations are so heavily dependent on executive interests and beliefs as to make the chance appearance of a change-oriented personality enormously important," Wilson argues that it is extremely difficult to specify a theory of innovation.[22] Finally, Posen argues that military mavericks can be important in assisting civilian inter-

vention by propagating interest in the technological innovation.[23]

Finally, the theories diverge on the issue of whether innovation is more successful during war or peace. Rosen supports peacetime as being more fruitful for military innovation. He suggests that peacetime military innovation occurs when respected senior military officers formulate a "new theory of victory" with intellectual and organizational components. Not only is this kind of ideological debate difficult to conduct during war, but lack of precedent also makes wartime innovation risky and infrequent. Rosen argues that when military innovation is required during war, it is because the nation is pursuing inappropriate strategic goals or the military has misunderstood the strategic goals.[24] Fitzsimmons and Van Tolz agree that militaries are driven to innovate during peacetime because "it is the period of least risk if wrong choices are made. Consequently, long periods without major wars have generally resulted in the greatest changes."[25] In contrast, Posen argues that technology tested through direct combat experience—by a client state or better yet by a state itself—can cause innovation. New technology that is not employed in a war is less likely to serve as a catalyst for doctrinal or organizational change. Wars can also increase innovation if a military suffers defeat, because such failure will alert civilians that something is broken and needs fixing.[26]

Overall, Posen concludes that innovation comes from outside the military through civilian intervention, especially during periods of high threat, after military defeat or in preparation for national expansionism. Rosen asserts that it comes from within the military through top-down influence of senior military leaders. Cote argues that military innovation is most likely during high threat and accompanied by the perception of limited resources with which to balance against the threat. In general, no one theory of innovation has been proven dominant. The fact that each author cites different cases in his work

demonstrates that innovation occurs, albeit rarely, but that no single cause can be identified. Therefore, all of these hypotheses will be kept in mind during the analysis of ATCCS.

The Current RMA.

The notion of military revolutions grew from Soviet writing of the 1970s and 1980s. Early studies talked of a "military technical revolution," but this quickly developed into the more holistic, synergistic concept of an RMA. Despite divergent views on military revolutions in general as outlined above, analysts agree overall about the defining characteristics and components of the current RMA. The current RMA, which some analysts believe is already more than 20 years old, developed as the result of precision weaponry linked with knowledge.[27]

> The emerging RMA in mid- to high-intensity warfare is centered around the fusion of sophisticated remote sensing systems with extremely lethal, usually stand-off precision-strike weapons and automation-assisted command, control and communications. . . . This fusion is expected to allow smaller military forces to attain rapid, decisive results through synchronized, near-simultaneous operations throughout the breadth and depth of a theater of war.[28]

Admiral William A. Owens, the former Vice Chairman of the Joint Chiefs of Staff, asserts that the technological innovations of the current RMA fall into three categories: intelligence, surveillance and reconnaissance (ISR); advanced C^4I (command, control, communications, computers and intelligence); and precision force weapons. These three technologies together will form a "system of systems."[29] "Fusing and processing information—making sense of the vast amounts of data that can be gathered—will give U.S. forces what is called dominant battlespace knowledge, a wide asymmetry between what Americans and opponents know."[30]

Scholars generally concur that the current RMA has four defining characteristics. The first—precise, stand-off conventional strikes—is the least radical of the capabilities associated with the RMA. Mazarr calls this "disengagement," or the process of conducting military operations at a significant distance from the enemy. As Mazarr theorizes, disengagement has three larger implications. First, disengaged combat will reduce U.S. force attrition and hold casualty rates down. Second, it may create a hierarchy in enemy targets, such that enemy weapons with the longest ranges will be targeted first, because longer range weapons will have the furthest reach against us. Finally, it will place a premium on long-distance systems and will further "the trend toward the decline in importance of heavy, mechanized ground forces."[31]

The second characteristic of the current RMA is an increasing interest in information dominance. Many analysts within the military view information dominance as an adjunct to conventional warfare or as a force multiplier. Perhaps the most widely-quoted concept is Air Force Colonel John Boyd's observation-orientation-decision-action (OODA) loop, which refers to the C^4I network. Using the OODA loop offensively, a military can "enmesh [its] adversary in a world of uncertainty, doubt, mistrust, confusion, disorder, fear, panic, chaos. . . . and/or fold [him] back inside himself so that he cannot cope with events/efforts as they unfold." The real objective is to complete the friendly OODA cycle faster than the adversary can complete his.[32] Fundamentally, this requires that a military organization have a doctrine for handling and processing information and empowering commanders with fused, real-time knowledge about the battlefield.

Some analysts view information as more than simply a tool for operational control and increasingly consider it a strategic asset. This is a much broader view of information dominance, reflecting Alvin and Heidi Toffler's view that information is becoming the basis of economic strength. The Tofflers describe history as progressing through a series of

waves; each wave and its wars are based on the means by which wealth is created. Thus, in their neo-Marxist view, during the "First Wave" of human development, production was primarily agricultural, so war sought to seize and hold territory. During the "Second Wave," industrial production dominated, so war was a struggle of attrition in which opponents sought to wear down each other's capacity to feed and equip mass armies. Following this logic, "Third Wave" warfare will seek to erode or destroy the enemy's means of collecting, processing, storing, and disseminating information.[33] There are some significant problems with their simplistic argument, not the least that the Third Wave seems still to be depending on Second Wave industrial-era economics and wealth-creation processes.[34] Despite factual inaccuracies and little attention in the scholarly literature, the Tofflers' book has received tremendous attention from within the government and is required reading in the curricula of three service war colleges.[35]

The third characteristic of the current RMA is "synergy," or "jointness" to use the more common term. In this context, synergy is intimately related to information dominance. Communication is essential for synergy to exist, which requires that all American military services—as well as those of our allies—have the ability to communicate on integrated, inter-operable systems. Integrated C^4I systems are only the beginning of a broader integration between the services' missions and roles. Mazarr posits that "over time, the evolution of synergy within the military . . . might overwhelm the current roles and missions debate. . . . Synergy should not be perceived as rooting out all aspects of redundancy, but rather making the various forces work better together."[36]

The final characteristic associated with the current RMA is civilianization. This characteristic encompasses two aspects: a reduction in the number of casualties and collateral damage associated with military combat operations,[37] and a blurring of the distinction between military and civilian endeavors. "Future warfare will be

information warfare, and it is therefore built upon a foundation of civilian technologies."[38] Simply stated, warfare is the practice of focusing the state's power in a particular direction to achieve strategic goals. Throughout history, this has usually been accomplished by applying armed formations to achieve the purposes of warfare. Civilianization suggests that new technologies may require a state to bring nonstandard actors into the conduct of warfare. This in turn may change the definition of a "warrior" or "warrior culture" so that those sitting behind computer screens are making a more direct contribution in future battles—perhaps even on par with those involved in close combat.

In sum, the current RMA encompasses four principles—disengagement, information dominance, synergy, and civilianization. As will be shown below, the Army has begun to address some of these principles through the ATCCS program.

TOS, TACFIRE and ARTADS: The First Three Generations.

> It has always been assumed that there are certain events the commander cannot know about while they are taking place on the battlefield. . . . This real-time information gap has been filled by intuition, the hunch, seat-of-the-pants brilliance, the courage to make critical decisions on the basis of incomplete information—and luck. This has been as true in Vietnam as it was that summer [of 1914] on the Marne. But as the Machine Age has given way to the Computer Age, a quiet revolution has been taking shape in the U.S. Army, one that promises to cut through the confusion of battle in a fundamental way. It comes under the rubric of ARTADS...and presages not only a revolution in technology, but in methods of command, military organization and human attitudes.[39]

In this 1972 article, Ludvigsen was introducing ARTADS—for Army Tactical Data Systems—a tactical command and control system to automate fire support, coordinate air defenses, ease friendly situational aware-

ness, and standardize reporting. ARTADS comprised five systems, at various stages of a fragmented development cycle: the Tactical Operations System (TOS), the Tactical Fire Direction System (TACFIRE), the air defense command and control system (Missile Minder), the Army Security Agency's Control and Analysis System (CAS), and the combat service support system (CS^3).[40] Established as a cohesive program in April 1971, ARTADS was the Army's third generation of automated C^2 systems.

The first generation was a program called Fieldata, a comprehensive computer-communications program that envisioned the coupling of on-line computers and communications systems in worldwide networks. Initial work on the Fieldata program and its MOBIDIC (Mobile Digital Computer) family started a few years after the conclusion of the Korean War. Despite rapid progress, the Army canceled Fieldata during its 1962 reorganization when Fieldata's funding was eliminated.[41] At about the same time, in response to a request from the Pentagon, the Command and General Staff College (CGSC) prepared a comprehensive plan, called "Command Control Information Systems 1970" (CCIS-70), to integrate automation into the battlefield. The CCIS-70 examined five battlefield functional areas—maneuver, intelligence, fire support, air defense, and combat service support (personnel and logistics)—as candidates for automation. In 1964, the Army implemented CCIS-70 as the Automatic Data Systems within the Army in the Field (ADSAF). This second generation of automated C^2 systems envisioned developing three systems: TACFIRE—for fire direction, TOS—for maneuver and intelligence, and CS^3—for combat service support.[42] This alignment continued in the third generation (ARTADS), but in ARTADS the most important systems became TOS, TACFIRE, and Missile Minder. Although ARTADS is beyond the scope of this paper, some aspects of TOS and TACFIRE development are important in light of the later ATCCS systems.

TOS, whose development started in the mid-1960s, was originally conceived to standardize reporting upwards and disseminate five-paragraph operations orders downwards. Maneuver commanders had realized that the reporting between levels of command was too slow. As the keystone system in ARTADS, TOS was to be interoperable with TACFIRE and Missile Minder. The initial effort was the Seventh Army TOS in Europe. After little success, the Army sought to apply TOS to a lower level of command and therefore in 1975 brought 7A TOS to Fort Hood to become the Division Tactical Operating System (DTOS, or TOS2).[43] At this point, TOS2 and TACFIRE shared a common hardware platform, but TOS2's software for intelligence and maneuver functions did not perform to required standards. Thus, in 1978, Congress canceled the $100 million program.[44]

In 1960, the Army started developing TACFIRE, to automate the process of field artillery support to maneuver forces. In 1967, the Army awarded its first Total Package Procurement (TPP) contract to Litton Industries. This contract covered development as well as all subsequent production, in effect ruling out any future competition for TACFIRE's production. The original TPP contract was very ambitious, spanning a mere 69 months, with the first systems to be delivered to the Army for testing after 22 months.[45] Needless to say, this schedule proved too ambitious and slipped tremendously. In his TACFIRE case study, Salisbury offers three major causes for slippage.

First, the TPP contract had an incentive structure which allowed the contractor to opt for improved system performance at the expense of increased cost and a stretched out time schedule—which the contractor did, as it was in his profit interest to do so. Second, in 1971 when TACFIRE shifted to the ARTADS program office at the Electronics Command at Fort Monmouth, software development remained under the Computer Systems Command (CSC) at Ft. Belvoir. This effectively split the program between two major commands, as CSC was not

part of the Army Materiel Command. This division in command was exacerbated by the physical distance between software and hardware development.

Third, and most importantly, TACFIRE contract management was supposed to be maintained through a series of reviews; no intermediate deliverable items were included prior to the actual system deliveries. Then, when Litton finally delivered TACFIRE, government testing organizations completed formal, methodical and intensive tests based on the AMC's published Qualitative Material Requirement (QMR) for TACFIRE. After the test period, the Army returned TACFIRE to Litton to correct the Testing and Evaluation Command's (TECOM) list of deficiencies. This process of sending the system back and forth between the contractor and the testing community caused serious schedule delays and frustrated the field artillery community, which had been expecting the system since 1960.

Finally, in August 1973—about the time when the original contract had planned for full-scale production to be completed—the Army sent out a formal message designating the Field Artillery Center as "the using agency for TACFIRE" and assigning it with the specific task of reviewing all TECOM reports to "determine from the user standpoint the minimum acceptable level of performance required in each deficient area."[46] This decision was a landmark for information systems development, because it drew the real user into the development loop for the first time.

Before this time, the prevailing method for designing software was "waterfall development," in which the contractor collected all of the requirements, completed systems design once and delivered a final product. Because of waterfall development's ease for funding and design, it was preferred—and arguably still is—by the developmental/testing community, contractors and Congress. With TACFIRE, waterfall development was replaced by "spiral development," in which the contractor collects some

requirements; develops, tests and fields an interim product; and uses information from this process to define requirements further.

Spiral development—which Salisbury called "Find, Fix, and Test"—"sought to collapse [the development-testing] cycle into much shorter intervals, handling fewer problems at a time, and, with the aid of the user and tester, providing early feedback to the contractor as to the adequacy of his solutions."[47] Despite these innovations in TACFIRE's development cycle, when it was finally fielded in 1980, the testing community was still unsatisfied with the final product, and the Government Accounting Office recommended delaying full-scale production until more hardware and software deficiencies had been corrected.

This short summary of TOS and TACFIRE illuminates five characteristics which were to become a pattern in subsequent Army automation development and acquisition. First, as Wilson and Heitzke argue, ARTADS systems were needed for two reasons: externally, a highly mobile enemy with modern weapons increases the battle tempo and necessitates a rapid reaction capability, and, internally, an overwhelming supply of information cannot be evaluated and processed manually in time for a commander to make his decisions.[48] Second, the Army set out to develop and acquire systems for which a mature technological capability did not yet exist. Thus, these grand visions—which were not yet technologically feasible—were exacerbated by optimistic testing and development schedules. Third, the Army imposed a rule that the main contractors for TACFIRE and TOS be mainframe manufacturers, which points to a bias in early development towards hardware and may have contributed to the software development and hardware-software integration problems which plagued both systems.[49]

Fourth, this misunderstanding of the software development process exacerbated the testing procedure. As Salisbury noted,

> the testing system has still not matured in its understanding or accommodation of software-based systems. A "perfect" software system of any magnitude with zero deficiencies has yet to be developed, either in the commercial world or in the military . . . Management decisions must be based on enlightened qualitative judgments rather than a simple quantitative tally of deficiencies.[50]

As a result, the testing process was more attenuated than it needed to be, which created great tension between the testing community and the practitioners in the field who would use the system. While TECOM focused on having a methodical, intensive, thorough, and cost-conscious acquisition process to ensure that all stated requirements were met, the field artillerymen were impatiently waiting to train with TACFIRE. Salisbury argued that the solution to the problem of developing highly complex systems was Find, Fix, and Test, because this procedure drew end users into the process and allowed for incremental improvements.

> The significance of the designated user cannot be overemphasized. Here for the first time was a single focal point within the Army empowered to speak with virtually final authority on modifications to TACFIRE. . . . This new procedure allowed the designated user to ask not "does the system do what the QMR says it must," but instead "is the performance of the system adequate to fulfill the needs of the field artillery?"[51]

I argue that these five characteristics—the need to develop a rapid reaction capability to fight a mobile enemy, the tendency to envision systems which were not yet technologically feasible, the bias in early development towards hardware, a misunderstanding of the software development process, and the resulting tension between the developmental/testing and user communities—were never adequately addressed and appear again in the development of later systems.

Sigma Star: The Fourth Generation.

Facing a canceled TOS program in 1978, then Brigadier General Emmett Paige and then Colonel Alan Salisbury, newly assigned as TOS program manager, tried to salvage the pieces of C^2 automation. Paige—who later retired as a lieutenant general and recently served as the Assistant Secretary of Defense for C^3I—and Salisbury recycled two TOS micro-computer-based components—the Tactical Commander's Terminal (TCT) and the Tactical Commander's Station (TCS)—to create the Maneuver Control System (MCS Sigma). As with TOS and TACFIRE, MCS Sigma and the other Sigma Star systems faced a continual tug-of-war between different Army communities—the users and the testers—with different goals and different incentives. On the one hand, the developmental/testing communities—including contractors, systems engineers, TECOM and AMC—were motivated by a disciplined, developmental approach, an interest in thoroughly testing the systems, and a desire to use resources wisely. On the other hand, the user community—including software developers and the practitioners in the field—wanted access to the new technology now, before a slow development and testing cycle and technological change rendered the systems obsolete.

A decade after ARTADS, the Army still sought a system that could provide horizontal integration of information on the battlefield across functional areas (BFAs). The Army articulated the horizontal function as a "force level control system" to provide an automated presence for each BFA at each command level, from corps to brigade. The new concept was called Sigma Star: "Sigma" to symbolize integration, as sigma is the classical mathematical symbol for integration, and "Star" to symbolize the five BFAs (maneuver, intelligence, fire support, air defense, and service support). Each point of the star would eventually have its own command and control system; at that time, some version of automated control already existed for each BFA except

combat service support. Salisbury noted that the original briefing slides for Sigma Star resembled "Starship Enterprise charts," because they depicted stacked stars, one for each level of command, within a three-dimensional space.[52] Like TOS in ARTADS, MCS Sigma was supposed to be the keystone to Sigma Star. Eventually the system's designers understood that they needed to keep the commander in the center of the system. As retired Lieutenant General Robert Donohue noted, this slight shift in the project's ideological underpinning became graphically represented on briefing slides with a soldier depicted in the middle of Sigma Star.[53]

The organizational and operational vision behind Sigma Star was especially prompted by doctrinal changes that were developing at TRADOC. In July 1977, General Donn Starry—a former V Corps commander in Frankfurt—assumed command of TRADOC. Starry's command experience—especially his concern about the Warsaw Pact's second echelon and follow-on forces—extended TRADOC's appreciation of its doctrinal tasks into wider and deeper dimensions.

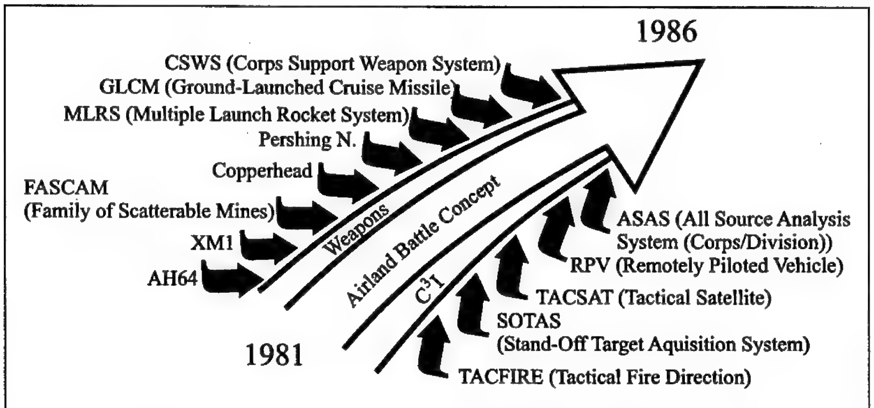
> Given the situation of active defense against a major, armor-heavy attack by the Warsaw Pact forces, Starry envisioned the corps' response in terms of a structured Central Battle, which he defined as that part of the battlefield where all elements of firepower and maneuver come together to cause a decision. ...Starry's corps overview in the Central Battle, his command goal to describe it analytically and his desire for a battlefield technology plan set this goal in the mold of a major plan, to be assembled by a systems approach.[54]

Intelligence indicated that the Warsaw Pact's second-echelon and follow-on forces would "line up" in somewhat predictable patterns, to exploit the first-echelon attack, and Starry believed that these follow-on forces could be "target-serviced" by corps.[55] Therefore, Starry conceived of the "critical tasks of the Central Battle" as target-serving, air defense, suppression-counterfire, command-control-communications-electronic warfare, and logistical support.

These concepts—which imagined a deeper battlefield with a requirement for near real-time C^2 synthesis capability—were published as part of the Battlefield Development Plan and distributed throughout the Army in November 1978.[56]

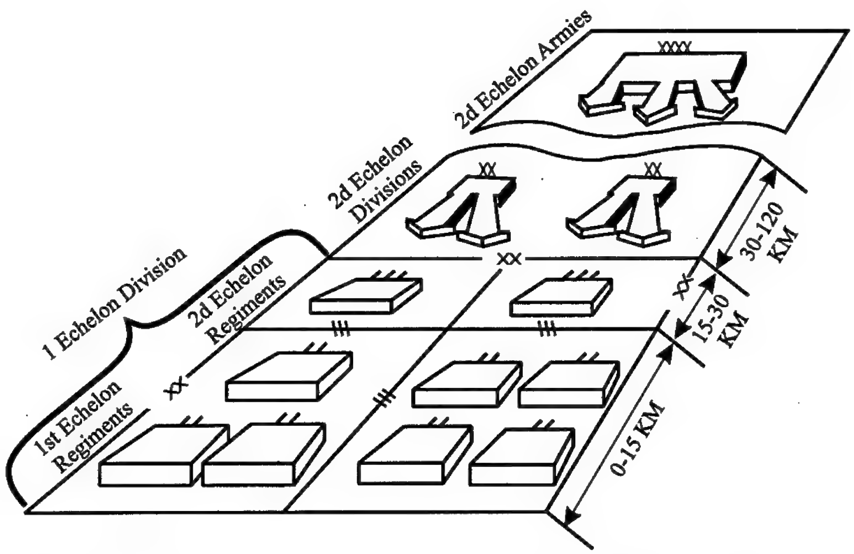
In March 1981, Starry formally published the operational concept for AirLand Battle and an operational concept for Corps 86. Romjue elegantly summarized the message of these March 1981 concepts in a few points. (See Figures 1 and 2.)

> First, deep attack was not a luxury, but an absolute necessity in order to win. Second, deep attack required tight coordination with the decisive close-in or assault battle, and with the rear battle so that the scarce means of attack would not be wasted on attractive targets whose destruction actually had little impact on the end result. . . . Third, *the concept required an alert mental grasp of the potentialities of the new Army 86 equipment already in production and oncoming. Commanders had to have the feel of its greater lethality and range, the more responsive command and control created by its automated systems, and exactly how the new sensor systems opened up new means to find, identify, and target the enemy deep and assess the results*. . . . Deep attack was necessitated by the nature of the Soviet operational maneuver. . . . the oncoming second echelon had to be slowed, disrupted, broken up, dispersed or destroyed in a deep battle. (emphasis added)[57]



Source: TRADOC Pam 525-5, *Airland Battle and Corps Operations - 1986*, March 25, 1981, p. 4.

Figure 1. A Substantial Step Toward Future Capabilities.



Source: TRADOC Pam 525-5, *AirLand Battle and Corps Operations-1986*, March 25, 1981, p. 6.

Figure 2. The Second Echelon Threat.

Above all else, AirLand Battle stressed the importance of continuous planning to integrate fire support, electronic warfare, deception and intelligence with maneuver. In other words, Central Battle needed a command and control system that would electronically link the five BFAs—just as Sigma Star envisioned.

The Army 86 equipment would provide such capabilities in the future, but there was a question whether existing equipment could. Starry's doctrinal review occurred exactly when many Army officers were reawakening after the "hollow Army years" to a Soviet threat in Europe. At the same time, the new technologies that had been promised since General Westmoreland's speech in 1969 had not yet seen the field. Starry's doctrinal modifications resonated with most practitioners and articulated their overriding concern: the smaller, professional Army of the late 1970s could not successfully defend against the larger Soviet bloc threat without new systems. As a result, the Army realized that the materiel development and acquisition cycle would have to run faster than before, "with accelerated fielding of

new systems running concurrently with both improvement programs and development of future systems. A total systems approach had to prevail."[58]

Back at the MCS Sigma program office—and concurrent to Starry's major doctrinal changes—Paige was attempting a new approach to fielding technology in the system's design and development phase. After Find, Fix, and Test's success in TACFIRE development, Paige and Salisbury believed that "evolutionary fielding"—spiral development—was the answer. The Army would field a baseline system—with an absolute minimum of new functions—to "real users" in tactical units rather than surrogate users in Army schools, as had previously been the practice. Then the real users, with Salisbury's team alongside them, would recommend improvements based on practical experience with the system. In response, improvements would be made systematically. To initiate this new scheme, in 1980 MCS Sigma software development moved to the Combined Arms Center Development Activity (CACDA) at Ft. Leavenworth, effectively locating software development with the users.[59] Cushman hailed the MCS Sigma fielding as the "Army's first success story in the use of evolutionary development."[60] The Armed Forces Communications-Electronics Association (AFCEA) seconded Cushman's conclusion in a 1981-82 study which came out strongly in favor of evolutionary development and an increase in real users' involvement in the process.[61]

The Army fielded the prototype MCS Sigma to VII Corps in Europe, which eventually tested it in the 1980 and 1981 Reforger exercises.[62] Dubbed the "Lunar Lander" by the troops, the prototype MCS was the "size of a stove with the memory of today's laptops" and could push data over tactical communications links at a rate of 1.2 baud. But as retired Colonel Michael Graves—the former operations officer of the signal battalion which tested the system—noted, none of his soldiers fully understood its capabilities, and so the system was used to automate other existing tasks such as serving as a "smart telephone." Nonetheless, it was the first

time a computer was used in a tactical operations center (TOC), and the first time that data was sent over tactical communications lines. "We didn't know it then, but it really was the dawn of C^4I," Graves said.[63]

Salisbury, who attended the Reforger tests of MCS, said the process was very productive, because it "got the system in the hands of troops as soon as possible."[64] MCS message traffic bettered older communications channels by hours and provided "such a clear command and control advantage as to distort the overall exercise."[65] (The computer-equipped team won.) Nevertheless, the testing community was unsatisfied with the system's results in the exercises, calling them "anecdotal evidence." The testing community wanted formal testing results, because Reforger did not provide any "quantitative measurement of how efficient the system is."

An anecdote from Reforger 1981 is illustrative. Retired General William E. Depuy, who was observing the exercise as a consultant, was present at an after action review with field commanders and representatives of the testing community. After an objection from a tester looking for quantitative results, Depuy turned to then-Major General Fred MaHaffey, the 3rd Infantry Division commander who had used MCS during the exercise. Depuy asked MaHaffey how many counterattacks his division had successfully launched during this Reforger with MCS. MaHaffey answered 20. Depuy then asked MaHaffey how many counterattacks his division could usually launch without MCS. MaHaffey answered, "only seven to ten." Depuy nodded and said, "That sounds like a minimum of a two to one improvement with MCS." Turning to the tester, he noted pointedly, "You want quantification, you got it." According to Salisbury, the Army made its decision to produce MCS partly as a result of this conversation.[66]

Meanwhile, field commands throughout the Army were busy with their own "front-end evolution." Tired of waiting for the Army Materiel Command (AMC) to eventually

deliver the fancy systems they were promising—and spurred on by Starry's doctrinal revisions and the renewed focus on the Soviet threat—commanders started purchasing off-the-shelf commercial gear and adapting it in their own commands to their operational uses. Three commands stand out as examples. First, the Communications Electronic Command (CECOM) sponsored the division-level Distributed Command and Control System (DCCS), which used off-the-shelf technology to create databases of tactical information. DCCS was fielded to the High Technology Test Bed 9th Infantry Division[67]—an experimental light division developed to counter a possible Middle East threat—which tested it in iterated field exercises through 1985.[68] Second, the 18th Airborne Corps created a Tactical Information Control System comprised of 20 Apple-II workstations under the control of the corps operations officer (G3). These computers automated corps-level logistics, command and control, and even had links into the worldwide ARPA net. Perhaps most importantly, Forces Command used "training funds" to adapt the Apple II computer into a system called Microfix to aid division and corps G2 sections. By the end of 1984, Microfix had been assigned an Army stock number, its repair parts appeared in the supply system, and a substantial number of them were being used in field commands.[69]

This mushrooming of front-end initiatives led to the formation of the Army C^2 Initiatives Program (TACIP) at the Combined Arms Center (CAC) at Ft. Leavenworth. TACIP established procedures for tracking field commanders' initiatives, identifying and funding the most promising projects and terminating those which lacked promise. By placing TACIP under CAC—the nominal voice of the practitioner community—the Army was sending a message. Just as moving MCS software development to CACDA located it with its users, creating TACIP under CAC circumvented AMC's centralized acquisition bureaucracy and encouraged practitioners in the field to experiment and innovate.

In 1984, the Army Training and Doctrine Command (TRADOC) and AMC wrote a joint pamphlet called "Non-Development Item (NDI) Acquisition" to standardize an Army-wide process for rapidly acquiring or adapting commercial off-the-shelf equipment without a lengthy R&D cycle. The preface to this pamphlet read in part:

> Greater reliance on NDI types of acquisition is the wave of the future. No longer can we continue to use the traditional heel-to-toe development life cycle management approach to satisfy most of our materiel requirements. It takes too long and time is money.... Certain technologies are advancing so rapidly that we can find ourselves fielding equipment several technological generations behind what is currently available.[70]

With this pamphlet, the Army in effect was creating doctrine for procedures that had already become adopted throughout the organization. In the process, the Army also consciously abandoned its 15-year-old project called the Military Computer Family (MCF), a standard automation platform for multiple tasks being developed by General Electric, RCA, and Raytheon. This concept of NDI off-the-shelf computer adaptation to meet battlefield needs caused a stir in the defense industry. As one contemporary observer noted, "The onslaught of contractors trying to grab contracts for their own particular NDI computers for tactical use rivals the Oklahoma land rush."[71] Perhaps most importantly, the advent of doctrinal NDI acquisition forced the Army to abandon its goal of system interoperability. Each contractor tailored its product to a different sub-set of the automating Army community, with little regard for the ability to communicate among them. As Cushman warned in a critique of the Army's automation protocols that had developed by 1985:

> The protocol is detailed, binding and implacable. If it is not right, you simply do not pass information digitally. . . . Interestingly, when the different communities who purport to represent the artillerymen . . . and the logisticians, and the intelligence experts, and the air defenders . . . and the commanders and the operations officers and all the rest began

to develop protocols for sharing information within their various spheres, each community developed a different protocol. Hard to believe, but true. . . . The fundamental challenge of the technical community in modern times is to arrange the protocols so that these communities who share the conduct of theater warfare can communicate easily with one another in a world of digital information flow.[72]

Hence a paradox: although Sigma Star intellectually envisioned an integrated command and control system which would allow the five BFAs to communicate, the organization—because of the imperatives of organizational politics—pursued a course of action antithetical to this goal.

In sum, MCS Sigma and Sigma Star embodied many of the characteristics of earlier automated development acquisitions. First, just as ARTADS was conceived to provide rapid reaction capability to fight a mobile enemy, Sigma Star was designed for a similar purpose. Its developers hoped, in Clauswitzian terms, to minimize the "fog of war"—or in the language of the current RMA, to maximize the friendly OODA cycle. They also tailored the system to counter the largest perceived threat, Warsaw Pact armed forces streaming across the Fulda Gap. With these two ideas, much of the intellectual innovation of later Army automation plans—adapted from ARTADS—was already incorporated in the Sigma Star concept.

Second, the evolutionary ("spiral") development concept used with MCS Sigma exacerbated an already-tense relationship between the user and tester communities. As with ARTADS, the testers were motivated by a disciplined, developmental approach, an interest in thoroughly testing the systems, and a desire to use resources wisely. In contrast, the user community—reawakening to the Soviet threat being articulated by General Starry at TRADOC—wanted access to the new technology now. Senior Army leadership tacitly approved of and encouraged these user-level initiatives by creating TACIP at Ft. Leavenworth. Suddenly, the entire service wanted to overthrow the deliberate, bureaucratic acquisition process, to ensure that

systems were not already technologically obsolete when they reached soldiers. In other words, because centralized development under AMC had not worked, the Army decentralized activity to move development "forward," albeit imperfectly.

Yet this mushrooming of front-end initiatives had a cost as well. As with the earlier ARTADS and subsequent ATCCS systems, Sigma Star automation efforts had problems with intra- and inter-service interoperability and redundancy. Earlier systems had problems communicating with those of other services, but by the mid-1980s, the NDI acquisition strategy caused interoperability problems within the Army itself. Advances in technology had outpaced the lengthy acquisition cycle and caused a proliferation of temporary and incompatible systems throughout the Army. By the mid-1980s, these innovative efforts within various commands began to appear rash and improvised. As Cushman noted in 1985, Army theater-level C^2 systems "neither exploit the present capabilities of technology nor does the system for their development adequately provide that future systems will."[73] A backlash towards deliberate, disciplined, interoperable systems—the developmental and testing communities' domain—was beginning.

ATCCS.

ATCCS built upon the legacy of Sigma Star, which established a pattern of automation development and acquisition begun before the Vietnam War and laid the foundations for two later trends. First, most of ATCCS' intellectual conceptualization came from the Sigma Star period. I argue that until the next major organizational upheaval at the end of the Cold War, there was very little intellectual or innovative content added. Second, the tension between the users and testers continued in this period, with the developmental/testing communities having a larger influence than in the late 1970s and early 1980s.

Thus, a dichotomy between ATCCS as a concept and ATCCS in reality continued until DESERT STORM. To simplify the discussion, these two trends will be discussed in turn.

As a concept, ATCCS added little intellectual or organizational value to the Sigma Star idea. In May 1986, the name ATCCS replaced Sigma Star, but the program remained essentially the same: the five BFAs were each to develop a C^2 system which could communicate with the other BFAs horizontally and vertically. Although the Sigma Star concept had envisioned horizontal integration, the NDI acquisition plan had made that kind of coordination and interoperability almost impossible. Instead, each BFA had begun to develop its own system, with its own program office, its own defense contractors, and its own protocols. In effect, the BFAs were only connected by a star on the briefing slides. The ATCCS program was still under the Combined Arms Combat Development Activity (CACDA)—where it had moved during Paige's evolutionary development plan and Starry's Corps 86 concept. Therefore, the new program manager, then Colonel—now retired Major General—Gerry Granrude, tried to refocus on horizontal integration to solve the developing problem of "stovepipes":

> Stovepipes—communications from subordinate to superior—are inevitable in large bureaucratic organizations. . . . stovepipes are often a deceptively efficient way to operate. As a general proposition, significant economies of scale or synergistic new capabilities can be created by forcing horizontal coordination where it has not previously existed. It forces bright, capable people to look at problems from new perspectives.[74]

Like Sigma Star, the five ATCCS systems were to communicate using the standard U.S. Message Text Format (USMTF), which would allow them to generate, send, and receive messages automatically.[75] With such integration, ATCCS was supposed to become the "system of systems."[76] Retired Colonel Mitch Mitchell, who served as the program manager for ATCCS common hardware and software, defined the goal of ATCCS as:

> . . . to get all the BOSs [battlefield operating systems] to communicate so that we could be more responsive to the enemy threat. We were trying to lift the fog of war and to get within the thinking radius of the enemy. . . . If you can see him and make decisions before he does, you can lift your fog of war.[77]

In short, ATCCS was new packaging for an idea which had been fully developed for a decade.

At the level of development and acquisition, ATCCS was having mixed results. As mentioned above, by the time that ATCCS was "created," each BFA had developed a stovepiped system. Ford Aerospace (later Loral), Singer's Librascope Division, and TRW developed MCS. Magnovox, having beaten out a lighter system developed by Litton, built the Advanced Field Artillery Tactical Data System (AFATDS), TACFIRE's successor. Multiple contractors, including the Jet Propulsion Laboratory in Pasadena and Norden's Digital Equipment Corporation, were building the intelligence system, called the All Source Analysis System (ASAS). Loral used its Rolm Hawk computers to develop the Forward Area Air Defense C^3I System (FAAD C^3I), Missile Minder's successor. The automated system for combat service support was being developed under two names by two contractors: Burroughs was building the Tactical Combat Service Support System (TACSS), while General Electric was developing the Direct Army Support System (DASS).[78]

To hasten the integration of the five BFAs, in May 1987 the Army announced that all ATCCS computers would be required to operate on a common hardware and software development platform. The Army chose AT&T's UNIX-5 operating system to serve as the basis of the common software applications. Miltope, to the surprise of many watching the defense industry, won the contract for the common hardware and software in August 1988.[79] The Army decided that MCS, AFATDS, FAAD, and the two combat service support systems would transition to Miltope's common hardware and software. In the process,

new contractors bid for, and in some cases won, the right to build the new common systems. Only ASAS, the intelligence system, was not required to transition to the common hardware-software—perhaps because the Army intelligence community understood its future lay in automation and thus was more proactive about its respective ATCCS system's development than any other BFA.[80] As Retired Colonel Dominick Basil, a former Deputy Commander at CECOM and former project manager of the SINCGARS radio system, noted: "ASAS worked well because its domain experts wanted it to work and needed it to work."[81] Even today, ASAS has not yet moved to the common hardware and software; this switch will finally take place when the Army fields ASAS Block II in 1998—more than a decade after the Army levied the original requirement.[82]

Despite their separate development histories, the five systems shared common development problems. As with TOS and TACFIRE before them, the biggest stumbling block, according to Mitchell, was in the development of each BFAs application software (especially for MCS). A vicious cycle—referred to as "requirements creep"—ensued in which the civilian contractors would develop software, the Army customers would change their stated requirements, and then the contractors would need to modify development. "We in the military have a tendency to constantly change requirements, which is hard for the civilian contractors to accommodate. . . . At some point, the military needed to baseline its requirements and run with it."[83] This was complicated by systems flunking operational tests, yet being developed further before meeting the standards. For example, a review of AFATDS in August 1987 showed that the system's timeline had slipped 2 years to 1993 fielding because of Magnavox's poor performance. By April 1988, Magnavox was spending about $1 million per month of its own funds to try to repair the project.[84] Such blunders not only caused the ATCCS programs to rotate leaders often, but they also lay at the heart of a handful of decisions by Congress to delay, suspend, or delete ATCCS funding.[85] By

October 1990, the Senate froze all spending on ATCCS development, because the five BFAs had not yet complied with the 1987 plan to transition to Miltope's common ATCCS system.[86]

This acquisition nightmare led to the wasteful purchase of extra hardware and peripherals, which were frequently rendered obsolete by the time the software had been debugged. As Mitchell succinctly stated the problem: "You can't buy the boxes until you have correctly developed the software."[87] These misspent funds contributed to a spate of scathing studies from the Government Accounting Office (GAO). Some of their findings included:

1. Unable to develop its full complex ASAS computer, the Army opted to build an interim system meeting minimal capabilities for the European theater against the potential Soviet threat. GAO charged that the interim system, called Warrior, could not even meet the bare minimum requirements.[88] In another study, GAO found that the intelligence community at Ft. Huachuca was building a third system—called Hawkeye—because they did not like the bulkiness of the original ASAS system. These three versions of the same system were not interoperable.[89]

2. Both ASAS and CSSCS were advancing to production stage while their systems were still failing tests. Both systems were advanced after failing the minimum requirements for connectivity with other ATCCS systems. The ASAS collateral enclave—the only portion which operates at the common ATCCS security classification level—was never even used in the tests.[90]

3. When MCS was tested in early 1990, the Army Operational Test and Evaluation Command found that the system "has not demonstrated its effectiveness in providing timely, accurate, and useful information in a battlefield environment." In addition, GAO noted commanders who had used MCS indicated that it "provides little to no aid in controlling maneuver forces."[91] GAO claimed that the

initial deployment of MCS computers had been used mostly as only a very expensive way to relay facsimile messages.[92]

4. After years of developing a rugged PC-based Common Hardware standard computer, the Army needed much more capacity and accepted bids for a Command Hardware (CH)-2 program. GAO charged that the Army had failed to justify the costs or prepare an adequate test of CH-2. GAO also criticized the Army for planning to field CH-2 only to heavy divisions, which could skew its design. Without fielding CH-2 to all types of divisions on all five ATCCS systems, the Army was in effect forfeiting its original goal of a standard battlefield computer and software.[93]

As an audit agency, GAO's natural proclivity is to overstate problems. Nonetheless, ATCCS acquisition and development was not successful during this period.

In sum, Army automation during the late 1980s remained paralyzed by the tension between the testing and user communities that had existed since TOS and TACFIRE. As the previous section explained, there was a widespread view by 1985 that the user community's free reign over technology acquisition had gotten out of control. As a result, for the rest of the 1980s, there was steady movement to rein in the users who had encouraged the reckless development of stovepipes. From the Army's 1987 decision to establish a common ATCCS hardware and software to the scathing GAO studies about fiscal abuses and testing failures, ATCCS development during this period steadily returned to the developmental and testing communities' domains. The cost of this deliberate development and acquisition, however, was that technology continued to outpace ATCCS. For the first time, the commercial sector replaced DoD on the cutting edge in information technology—a fact which DoD refused to recognize and counterproductively fought for some time. As the next section will argue, the Army did not wake up to these shortcomings until the twin milestones of the early 1990s—DESERT STORM and the end of the Cold War.

After the Cold War: ATCCS in the Army Battle Command System.

By the time the Army was preparing for Operation DESERT STORM, the ATCCS program was mired in bureaucratic paralysis. Of the five BFA control systems, only MCS had been fielded to regular units; the four other systems still remained in their development and testing cycles. And in a move surprisingly similar to the Microfix acquisition during the NDI era, the intelligence community had adapted and fielded Warrior—a stop-gap system used in the European Central Region and taken to the Persian Gulf. As in previous periods of Army automation, two themes continued to characterize ATCCS after the Cold War. First, despite the major geopolitical changes of the post-Cold War era, ATCCS' concept was fundamentally identical to the old Sigma Star vision. Second, the perpetual tug-of-war between the developmental/testing and user communities continued to hamper ATCCS' development and acquisition process. What did change, however, was the balance between the two communities. As in the late 1970s, when the Army reawakened to a large Soviet threat and General Starry articulated a real need for technological improvements, the end of the Cold War tipped the scale back in the user community's favor. Just as senior Army leadership created TACIP in the early 1980s to place innovation authority and resources with CAC and the user community, senior Army leaders in the early 1990s followed similar tactics. Once again, as the pendulum swung away from the methodical, disciplined development of systems engineers to field officers chafing on their technologically-outdated systems, the user community gained control. This section outlines the "revolution" which culminated with Force XXI.

DESERT STORM has been hailed as the first example of "Third Wave" warfare, a preview of war in the Information Age. Yet it is equally possible to categorize the conflict as the last "Second Wave" war, as van Creveld does:

In Operation DESERT STORM, units moved hundreds of kilometers in a matter of days. This compares well with Soviet operations in the latter part of World War II and in Manchuria in 1945. DESERT STORM, however, was more movement than maneuver, in part because the Iraqis themselves proved so passive. Given their passivity, tempo—the notion of entering into the enemy's observation-orientation-decision-action (OODA) cycle—never came into play. Tempo embodies the concept of acting before the other can react. The concept does not have much meaning if the other hardly reacts at all.[94]

Van Creveld argues that the Army would not have been able to exercise tempo had the opponent been more active, because it seemed "more interested in synchronizing the moves of its own components than in vigorously exploiting battlefield success by sending spearheads forward."[95]

One reason for this criticism might have been the proliferation of stovepiped systems during the 1980s—a different contractor with a different C^2 system for each different sub-community. DESERT STORM demonstrated intense problems with inter- and intra-service connectivity and interoperability. This lack of connectivity was a contributing factor to the fratricide of friendly troops, which sparked bad publicity for the military. In short, the American people would not tolerate friendly fire losses from arguably the most technologically advanced armed force in the world. The military—and especially the ground forces—needed to fix this problem. That the U.S. military had problems with "situational awareness" and C^3 interoperability in the Persian Gulf was even more apparent in comparison to the much less technologically advanced Iraqi military. The question arose: if the U.S. Army has such a technological advantage, why isn't the technology being used to minimize the fog of war?

In the course of Operation DESERT STORM, the Army saw smart weapon technology overpower opponents in terms of time, distance and mass, but noted deficiencies in the command and control of these weapons, particularly for the lowest echelons. The lowest command levels were not

situationally aware of all of the activity in their immediate area of interest. The Army needed improvement in combat identification, fratricide prevention and information sharing between ground and air weapons platforms to enable commanders to conduct both close and deep combat.[96]

Among the "lessons learned" from DESERT STORM, this was perhaps the most important. As General John H. Tilelli, Jr.—a former division commander in DESERT STORM and then the Deputy Chief of Staff for Operations and Plans (DCSOPS)—testified before Congress in 1994, "a key problem in the desert—combat identification and situational awareness" could only be solved "by precisely locating everyone on the battlefield." This admission to Congress stood out from the rest of Tilelli's testimony, which was relatively complacent and status quo: the Gulf War had validated AirLand Battle doctrine, Army training strategies at NTC and other training centers, and the "Big Five" weapons systems—the Abrams tank, the Bradley Infantry Fighting Vehicle, Patriot missiles, multiple rocket launchers and the Apache attack helicopter. Perhaps doctrine needed a slight tweak for the joint environment, and perhaps strategic mobility capability could use some improvement,[97] but on balance, the Army was well perched for the next war—as long as the battlefield looked roughly the same.

The Army's poor performance with "situational awareness" during DESERT STORM set the stage for organizational change and information technology innovation. However, it was the convergence of the DESERT STORM "lessons learned" with two other factors that caused Force XXI. The first was a geopolitical change in the international balance of power. The end of the Cold War effectively shattered the Warsaw Pact threat towards which AirLand Battle and the Army 86 modernization had been geared. Second, a group of senior Army leaders awakened to the decreased international threat and saw the writing on the wall. In an era of decreased threat and shrinking defense budgets, any military service without a revised

mission would lose to the other services. As under Starry, the Army needed a makeover to fight a new threat—except this time the threat was force reductions, not the Soviet Red Hordes. The two senior leaders most responsible for this face-lift were General Gordon Sullivan, then Chief of Staff of the Army, and General Frederick Franks, the TRADOC commander.

This synergism between the Gulf War experiences, the end of the Cold War, and new senior Army leadership created the right conditions for broad change. Sullivan and Franks claimed to be making an enormous change in the Army's organization and use of technology, but I argue that their statements may have been exaggerated. The story of ATCCS and battlefield C^2 is merely a part of the broader Force XXI vision; nonetheless, the course which ATCCS takes after the Cold War is fairly emblematic of the current RMA overall.

As General Starry was to AirLand Battle and Sigma Star, so General Sullivan was to information technology on the battlefield. As retired Colonel Dominick Basil said, "Without General Sullivan, it would have never happened. He was a zealot"; recasting the ATCCS project "matched his vision."[98] In December 1991, Sullivan created the Army Digitization Task Force to study the Army's use of information technology. The ADTF report recommended a substantial overhaul of the Army's current C^2 architecture and a renewed focus on battlefield digitization. Sullivan, who was heavily influenced by the Tofflers and other information warfare theorists, was receptive to these ideas. By the spring of 1992, when Basil—then deputy commander of CECOM—brought Sullivan a video conceptualizing digitization and situational awareness, Sullivan was won over. "We left the video on a Friday afternoon and he called me at home that night at 2200, completely ecstatic. "That is exactly what I need for the Army,' he said." The 33-minute video advocated two concepts: horizontally integrating existing C^2 systems and extending automation to the lowest echelons of the battlefield via a tactical internet.[99] Although

the first idea was hardly new, both concepts become the foundation of Sullivan's Force XXI.

At a broad level, Sullivan's vision accomplished two things. First, he provided the Army with the intellectual paradigm for redefining itself in the post-Cold War world. Without a Soviet threat to motivate funding for training and weapons procurement, Sullivan shifted the Army towards a new mission—force projection, "the demonstrated ability to rapidly alert, deploy and conduct operations anywhere in the world."[100] By 1993, he succinctly captured this new mission in five bullets: project and sustain combat power, protect the force, win the information war, deliver precision strikes, and dominate maneuver.[101] Second, Sullivan wrote about the impact that information technology could have on warfare, and he tried to incorporate technology into the Army's organization and doctrine. In March 1992, Sullivan announced his plan for the "Louisiana Maneuvers"—borrowing on General Marshall's and General McNair's 1940-41 organizational studies of the same name—which were to be a series of exercises:

> to shake out emerging doctrine, to experiment with organizational design, to train the mobilizing force, to provide insights on materiel requirements, and to develop leaders. . . . My goal is to posture our Army to protect the nation's enduring interests in an uncertain future. I believe we can accomplish our objectives by harnessing the power of the microprocessor. . . . Louisiana Maneuvers will be the laboratory in which we learn about the Army of the 21st Century.[102]

Over the next 2 years, Sullivan crystallized his ideas about the structure that a reorganized Army would need. In July 1993, he published the Army Enterprise Strategy, an assessment of existing C^4I systems and a comprehensive vision for the Army's role in the joint program "C^4I for the Warrior." The Enterprise Strategy articulated nine specific actions for reshaping Cold War era information and communications systems.[103] In March 1994, he published a campaign plan for Force XXI, which argued that the Army needed to embrace the power of information technology and

implement the current RMA. "The high ground is information. Today, we organize the division around killing systems, feeding the guns. Force XXI must be organized around information—the creation and sharing of knowledge followed by unified action based on that knowledge which will allow commanders to apply power effectively."[104]

In this campaign plan, Sullivan argued that the focus on information might require a redesign of the force at all echelons. "That is a very broad charter, and it is by no means clear that we need to make a radical shift. But it is clear that we must open our minds to the power of change and ask ourselves: 'What could be?'"[105] In Sullivan's view, the 21st century Army would need to be more versatile and strategically deployable. Units would need to rely on electronic—rather than geographic or physical—connectivity, and battle command would be based on "real-time, shared, situational awareness." Units may come in a different shape and size, with a lower leader-to-led ratio, but "responsibility will remain hierarchical and cannot be distributed." Reorganization would eventually affect all echelons, but it would begin with the division, the basic building block of the ground force structure in the information age. "The core competency of the division as an echelon is command and control . . . the division is about battle command and . . . battle command is about decisive victory—dominating battle space."[106]

The impact of the Force XXI campaign plan on the Army's organization and doctrine was significant. With this document, Sullivan commissioned a review of the division's organizational structure, with the plan to carry this review to other echelons of the force. Sullivan named Franks at TRADOC, in cooperation with the other major commands, to lead this redesign called "Joint Venture." Moreover, Sullivan assigned the DSCOPS with the task of institutionalizing some of the Louisiana Maneuvers lessons learned in Battle Labs, test beds to update the various battlefield functions which were located with each branch's school. Each Battle Lab's research would culminate in an

Advanced Warfighting Experiment (AWE). Finally, to effect the acquisition and assimilation of technology, Sullivan created the Army Digitization Office (ADO) to serve as the integrating mechanism for technology procurement and implementation. ADO's creation was enhanced by the publication of the Army Enterprise Strategy Implementation Plan, which provided a coherent structure to the previous year's Enterprise Strategy and established the Horizontal Technology Integration (HTI) initiative.[107]

One reason for Force XXI's "success" was General Franks, who understood and agreed with Sullivan's vision. Just as Starry's experiences commanding V Corps colored his tenure as TRADOC commander, so, too, did Franks' experiences in DESERT STORM. Most importantly, Franks brought with him a desire to fix battlefield C^4I. On February 7, 1992, Franks directed CAC to "review in detail and validate architecture requirements, programs and C^2 systems, with emphasis on C^2 mobile operations, in light of the need for a versatile, down-sized, post-Cold War Army." This study, initially intended as an abbreviated functional area assessment of the tactical C^2 systems, became a broader look to address the senior Army leadership's dissatisfaction with progress on ATCCS and its funding. In its ATCCS reevaluation, the Army determined that it needed a new vision to meet commanders' requirements in the Information Age. If ATCCS' goal was communications integration, "it needed to become more commander centered and commander supporting . . . to integrate several kinds of information, including near real-time, fused, relevant friendly and enemy information, and needed to provide user-friendly methods of applying or manipulating information."[108]

As a result of this study, CAC created the Force Projection Army Command and Control (FORCPAC^2) Action Plan to implement the study's objectives. FORCPAC^2 sought to create a technological foundation for the Army's new mission of force projection—seamless global connectivity. To become truly seamless, however, the Army

needed to overcome its entrenched pattern of stovepiped systems. FORCPAC^2 recommended creating integrated capability requirements and developing common software languages, standards, and protocols as part of the HTI initiative. In other words, FORCPAC^2 recommended (re)inventing the Sigma Star-era interoperability vision. FORCPAC^2 also called for the Army to move towards a commercial "common operating environment," using commercial hardware with common operating systems, application software, and information databases. This standard, called the Defense Information Infrastructure Common Operating Environment, was to use common off-the-shelf technology, which would not only establish economies of scale but create interoperability between various defense contractors.[109]

Concurrently, officers within CAC's Combat Developments section (CAC-CD) worked to define "battle command," the term to which Sullivan and Franks had become attached. They settled on "the expression of the commander's will, the way he formed his vision of the battle, how he was helped in fully picturing it, and how he anticipated and adjusted as information and events unfolded."[110] This idea became the core concept of the Battle Lab, a spin-off from CAC-CD. This lab morphed into the Command and Control Battle Lab and then into the Battle Command Battle Lab. As CAC historians argue, "in the process, more than the name changed. The Battle Lab changed from 'tinkering with the hardware' to studying, experimenting with, and developing the 'art' of Battle Command."[111]

Finally, in September 1993—2 months after Sullivan published the Army Enterprise Strategy—Franks completed a major review of the Army Command and Control System (ACCS), the Army's major C^2 architecture that spans from national to tactical levels and includes ATCCS. Despite unanimous agreement that the ATCCS vision from the Cold War was outdated, the Army feared Congress would abandon the old ATCCS approach after investing

decades of time and billions of dollars and not pay for a new initiative. Therefore, Franks chose to recast ATCCS with its various components' funding lines into a new integrated funding under a new name, the Army Battle Command System (ABCS).[112]

Under Franks' plan, ABCS should provide seamless connectivity from the squad level to the National Command Authority using Army, joint, and allied communications standards. (See Figure 3.) At the highest level, ABCS comprises the Army Global Command and Control System (AGCCS), which operates at the corps and theater levels and overlaps with the Joint GCCS. ATCCS operates in the middle echelons, from corps to battalion. The system operating at the lowest echelons—called the Force 21 Battle Command Brigade and Below (FBCB2) and recently tested in the EXFOR AWE—will span from brigades to individual soldiers via a tactical internet and applique—French for

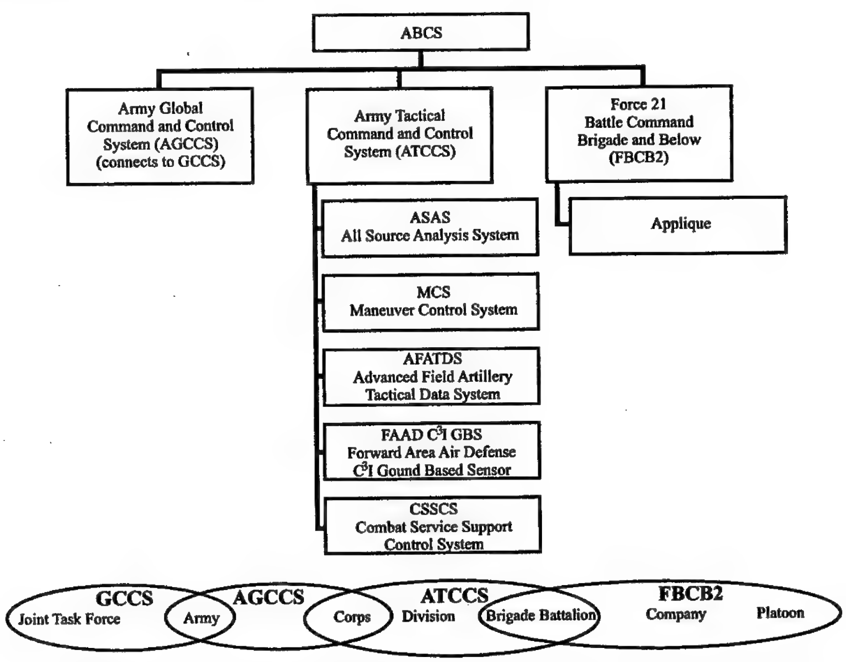


Figure 3. Army Battle Command and Control System.

"applied"—computers added to individual weapons.[113] ABCS embraces the "single point of entry" concept, so that once data has been captured in digital form, it can be shared "across echelons and geographic boundaries without being retyped or otherwise reentered."[114] Thus, the system should permit commanders at every level to share a common picture of the battlefield, scaled to their level of interest and tailored to their special needs.

As the successor to ATCCS, ABCS was to continue the "evolutionary acquisition"—spiral development—strategy of ATCCS development and procurement.[115] However, Sullivan realized that to create an integrated system, it needed to be under the control of one individual who would have the authority to standardize and compromise between different systems and different contractors. In July 1993, Sullivan appointed then Major General William Campbell as director of the Program Executive Office for C^3, responsible for development and acquisition of command, control, communications, and computers.[116] By unifying many disparate programs under Campbell and tasking him with the Battle Command AWE, Sullivan streamlined the bureaucracy surrounding battlefield C^2.

Under Campbell, numerous systems comprising ABCS—including the five ATCCS systems at various stages of development—have been fielded to the 4th Infantry Division, the Experimental Force (EXFOR) division created at Ft. Hood. The Army's strategy for digitizing the battlefield uses a bottom-up approach that experiments echelon by echelon with several systems simultaneously and involves brigade-, division-, and corps-level experiments. The Army sponsored a company-level AWE in 1993 and a battalion-level AWE in 1994 at Ft. Hood. In March 1997, EXFOR conducted a brigade-level AWE at the National Training Center (NTC), and it held a division-level AWE in November. Final plans for the digitized division and corps force structures should be completed early in 1998. The Army then plans to field its first "digital division" by

2000; by 2004, the Army hopes to field three digital divisions as part of the first digital corps.[117]

At the 2-week brigade AWE in March 1997, the Army tested ABCS and 72 other prototypes, many of them applique systems.[118] Major Marcus Sachs, the 4th ID's automation management officer, said the EXFOR brigade—equipped with 87 different digital systems—had more than 800 devices with internet protocol (IP) addresses. Of these, more than 75 percent were applique computers on individual weapon platforms or hand-held by infantrymen. Although the EXFOR faced the NTC's opposing forces (OPFOR) in the war game, the purpose of the AWE was to work out kinks in the systems. Therefore, the battlefield was relatively static, without cross-attacking units or relocating ("jumping") command posts.

Many of the appliques were applied in a temporary manner for the experiment; for example, the computer in the Abrams tank was mounted so that the crew could not fire its main gun—because it would recoil onto the LCD display.[119] Similarly, at its current stage in development, FBCB2 passes messages in a hierarchical manner (for example, all of the tanks in a platoon must communicate their locations through their platoon leader's and company commander's tanks). Therefore, although applique in theory should be able to identify friendly vehicles as "dead" or "alive," during the brigade AWE some "dead" platforms (such as a "dead" company commander's tank) kept their applique systems active in order to relay messages for the tactical internet.[120]

Initial AWE reviews were mixed. According to an Operational Test and Evaluation Office observation team, "there was no increase in lethality, survivability or operational tempo attributable to digitization." OT&E also suggested that fratricide may have been higher during the experiment: there were 32 incidents of fratricide during the AWE compared to a combined total of 28 for the three previous conventional NTC exercises. Moreover, electronic

warfare officers in the OPFOR said they could "detect and locate" EXFOR's tactical operations centers "twice as fast" as they could those of conventional brigades training at NTC.[121]

TRADOC Commander General William Hartzog dismissed these findings, claiming that the EXFOR's performance was "at least as good, and, in some cases, much, much better" than the three task forces whose NTC rotations preceeded the AWE. Hartzog said much of the fratricide increase occurred because the EXFOR fought 6 days longer than an average NTC rotation and had at least 1,800 soldiers more than most task forces. And in terms of electronic vulnerability, the EXFOR did better than anticipated, Hartzog said, and the Army has enough money to fix the problems within 2 years.[122]

Although the Army will compile official lessons learned over the next few months, six conclusions from the AWE can already be drawn. First, ABCS has the potential to "lift the fog of war." In an April 14, 1997, message to general officers, Army Chief of Staff Dennis Reimer estimated that EXFOR was able to use its sensors and other communications tools to see the battlefield correctly 80 percent of the time.[123] As a result, the battlefield picture on ABCS usually captured 95 percent of the "true" picture as seen on the NTC controllers' simulation control system ("Star Wars"). One reason for this high level of accuracy was the successful integration of the Global Positioning System (GPS) into the tactical internet. A weapon platform (or an individual soldier with a hand-held computer) would automatically transmit its location in three-dimensional space after 100 meters of movement or two minutes, whichever occurred first. Within seconds, this data would be propagated as an icon graphic on the battlefield map in all ABCS systems, from individual tanks to the division command center.[124]

Second, despite this immense improvement in situa-tional awareness, technology may point to a variety of inadequacies in doctrine. According to Basil, in one battle,

the EXFOR's unmanned aerial vehicle (UAV) showed the OPFOR still massed in its assembly area, a perfect target for an artillery strike. Yet it took the EXFOR 40 minutes to call for fire, by which time the OPFOR had already moved. "They should have had fire on it in 30 seconds, but the soldiers weren't trained on what to do with all of this data."[125] Although trained in the system's electronic procedures, EXFOR soldiers went into the AWE less trained in exploiting its potential. A related problem was that commanders did not always trust their computer displays, but instead went with their intuition. As Major Jerry Bradshaw expressed it, "Just because you have the picture in front of you doesn't mean that the reaction is automatic."[126] On the other hand, the technology provided a certain amount of comfort:

> [When] talking to a soldier about the applique and the new digital tools at his disposal, the soldier stated that he feels much more comfortable now, especially at night, driving alone in the desert. With his applique on and operational, he is no longer "alone." "I can see all of my other soldiers there on the screen and know that I'm not really all by myself in the middle of nowhere."[127]

Third, ATCCS worked relatively well. Sachs said that it was possible to log onto one system and pull information up via the client-server on another system. However, graphic overlays from one terminal cannot be edited on another, and problems remain with message formats, especially in the CSSCS. In many cases, the ATCCS systems would only populate the higher headquarters' computers if a subordinate computer sent a manual message. This creates problems for the lower-echelon commanders who are trying to fight the battle and do not have time to update the system electronically. This also slows the real-time picture of the battlefield, because only correctly formatted messages will automatically propagate the common database. Any messages with incorrect formats must be manually entered into the database, which slows the process considerably. One intelligence analyst who worked in the EXFOR tactical

command post (TAC) said that the battlefield picture was frequently two hours behind due to the unprocessed message backlog.[128]

Perhaps the largest ATCCS problem was with fire control in AFATDS. During the last battle, the OPFOR destroyed all of the friendly UAVs, although the EXFOR tried to call in a fire mission to kill the OPFOR's surface-to-air missiles. Unfortunately, the fire missions were never shot, because SA-8s were low on the priority of fires list and therefore automatically denied by the computer. This vignette had a big impact on the EXFOR, as one observer noted,

> I think that we as a community got caught up in the capabilities of the system and what it could do if those pesky humans weren't around to get in the way. What we need to remember is that the box is (or should be) designed to be a tool for the commander . . . with real tactical experience to use. The picture on the screen is useless without the experience to interpret it and make the right judgment based on the information presented.[129]

Fourth, a surplus of data does not necessarily equal knowledge. With such a high dependence on graphics, which require lots of digital memory, the ABCS network experienced significant bandwidth problems and communications chokepoints, as some links could only pass data at a 9.6 baud rate. Although ATCCS can finally do in 1997 what it was conceived to do in 1979—digitally pass the five-paragraph operations order—it took several hours to get the order down to the battalion level over such slow communications paths. ASAS crashed in the first battle, presumably because of an information overflow in the network. When this occurred, the analysts reached for their trusted tools: paper maps, acetate overlays, and colored markers.[130] As Sachs wrote, "It's a digital traffic jam out there now. Information discipline has gone to hell. It's quite possible that we are going to have to learn to communicate on the battlefield using the digital equivalent of a point paper. Simpler graphics will have to suffice."[131] Perhaps the

most eloquent expression of this problem came from Captain Leaphart:

> We have created an insatiable appetite for data. This may be insurmountable without a serious shift in philosophy on the part of senior level commanders. They want more data. We have continued to roll over for their demands of more data without forcing them to distill those demands into the real information requirements they need to operate. Data and information are NOT the same thing![132]

Fifth, EXFOR further extends a developing dependence on contractors, which raises questions about the Army's ability to support ABCS autonomously. This reliance on civilian contractors has raised considerable debate about personnel issues. According to Sachs, one plan being considered is to create an organization—headed by a lieutenant colonel and comprised of deployable contractor teams—which would provide all digital support for III Corps if any of its subordinate units were to deploy.[133]

Finally, the AWE is being touted as an experiment in acquisition reform; as former Secretary of Defense William Perry said during a visit to Ft. Hood in November 1996, "this [acquisition reform] has importance well beyond the Army."[134] What exactly is this reform in the development and acquisition process? The Army has brought together contractors, TRADOC developers, 4th ID soldiers, AMC acquisition officials, and ABCS program officers to create the Central Technical Support Facility at Ft. Hood. By placing all of the Force XXI systems in one building, "marrying up" the real users with the contractors, and running 24 hour operations, "in 2 years the Army was able to accomplish what it usually does in 6."[135]

The arrangement showed benefits soon after Force XXI's connectivity exercise. Soldiers discovered that the ITT-built SINCGARS radios squealed when in use and had a shorter range than specified when voice and data were sent over the same channel. ITT contractors returned to their lab and 6 weeks later delivered 1,600 new radios which operated to

the standards the Army required. Such an accomplishment usually takes 3-4 years, according to Colonel Thomas Metz, director of the EXFOR Coordination Cell and 4th ID chief of staff.[136] According to Sachs, this is a new approach, because the Army develops and fields a 20 percent solution and then gets immediate feedback before developing any further. "This way we can field equipment much more quickly and give the Army what it really wants," Sachs explained.[137] In other words, the Army has returned to spiral development—"evolutionary development"—as conceived in Find, Fix, and Test for TACFIRE in 1973.

In sum, since DESERT STORM and the end of the Cold War, the Army has made some progress in fielding technology, although it has not made similar progress in addressing the overall problem. Fundamentally, ATCCS and ABCS are still trying to solve the old dilemma from the Sigma Star era—how to lift the fog of war and speed up the friendly OODA cycle. Second, the perpetual tug-of-war between the developmental/testing and user communities continues to plague Army digitization efforts. However, the post-Cold War geopolitical situation and a turnover in senior Army leadership have again shifted the balance towards the users.

Sullivan's Force XXI had the same impact on technological development and acquisition as Starry's AirLand Battle and Army 86 programs. By empowering TRADOC and DCSOPS with force structure experimentation and information technology integration, Sullivan effectively moved resources and responsibility for innovation away from the developmental and testing communities to the user community. The Battle Labs—the functional equivalent of TACIP a decade later—were an effort to bypass the bureaucratic ossification of the weapons system development process and its many actors and to give innovation leadership and initiative back to CAC, the nominal voice for the user community. Franks articulated Sullivan's vision for Army C^2 systems by recycling the ATCCS program as ABCS, while Campbell pulled the C^4I

effort together into a single program, thereby minimizing interoperability problems. As with "front-end evolution" in the early 1980s, the user community—through DCSOPS—has been driving the innovation and experimentation in the AWE. Thus, while the five ATCCS systems still remain under different program managers and contractors, they have made progress during the AWEs and should transition to a common operating environment within the next 3 years.[138]

Conclusions.

But is ATCCS an innovation? Has ABCS successfully implemented the Revolution in Military Affairs? According to Sullivan in 1995, the answer to these questions is yes:

> The U.S. Army is responding to the ongoing revolution in military affairs. Force XXI is the Army's vehicle to create a paradigm for building a 21st Century Army which anticipates and leverages the changes inherent in this revolution. The name "Force 21" represents . . . three things: (1) a new conceptual construct about creating and fielding the entire force, (2) a process for implementing this fundamentally new concept, and (3) an open-ended series of successively improved versions of the Army. . . . The Army's Force XXI strategic objective captures the essence of the required changes described above: to transform itself from an industrial-age Army to a knowledge and capabilities-based, power projection Army which can achieve land force dominance across the full continuum of 21st Century military operations.[139]

In Sullivan's view, Force XXI is an innovation because it changes not only the structure of the organization but also the process by which the organization will continue to change in the future. For that reason—applying Sullivan's own definition to the case—I disagree. As this paper has suggested, the intellectual concepts behind ABCS and the "new evolutionary approach" to developing automated systems have been around since TACFIRE and TOS. Moreover, the tension between the user community and the developmental/testing communities has not abated, and the

tug-of-war between proponents of the waterfall and spiral development methods continues. The Army is aware of these problems. In congressional testimony in 1992, then-Assistant Secretary of the Army for Research, Develop- ment, and Acquisition Stephen K. Conver explained to lawmakers in an insightful statement:

> If we are to have successful programs, we believe we must resolve requirements issues between the users and developers before we start any program. We have observed that when our acquisition programs run into problems, the cause has often been a disconnect between the user's requirement and the acquisition strategy that was adopted (or the technology that was available) to meet that requirement. These problems take three forms: (1) *overreaching*—expecting the acquisition system to deliver results that are not achievable; (2) *overspecing*—burdening the acquisition strategy and the contractor with too much emphasis on "how" to meet the requirement and not allowing some flexibility; and (3) *push/pull*—the reluctance of some users to accept new technology that must be "pushed" or sold to them, in contrast to the familiar technology, which they willingly "pull" into their organization. (emphasis in original)[140]

Yet as Salisbury said in his TACFIRE study, "Many 'lessons learned' have come out of the TACFIRE program. Unfortunately, lessons learned too often become lessons forgotten. The Army falls short in its ability to retain a corporate memory and is frequently doomed to repeat its past mistakes."[141]

Sullivan's Force XXI, ABCS, and Battle Labs are new ways of putting together ideas that have been extant for several decades. ATCCS had the potential to be a successful innovation when it was originally conceived as Sigma Star in 1978, had technology been able to support the concept and had it not become mired in the bureaucratic tension between the user and developmental/testing communities. At its core, Sigma Star, ATCCS, and ABCS shared a dream—to minimize the "fog of war," or in the jargon of the current RMA, to maximize the friendly OODA cycle. Yet 20

years after its conception, implementation and execution are still flawed. In this regard, Starry and Sullivan shared an organizational savvy—both leaders were able to articulate the practitioners' frustration with a deliberate developmental process that fielded systems several technological generations late. Both leaders were able to engage the user community, shift resources and responsibility to it, and thereby neutralize the developmental bureaucracy. As this case suggests, the military is not a unitary actor, and one individual alone cannot override a large bureaucracy. To his credit, Sullivan may have realized that he could accomplish only so much during his term as Army Chief of Staff. To ensure a Force XXI "legacy," Sullivan needed to structure the debate so that it would outlive his tenure—he needed to raise questions and begin experiments that could not be easily undone in the future by his successors or the organization as a whole.

Nonetheless, neither Starry nor Sullivan enacted a "military innovation" as defined in the first section of this paper. Despite the attempts at digitizing the battlefield, the Army has not yet altered its core tasks nor displaced any of its combat platforms. While AirLand Battle in 1978 and Force XXI in 1994 required highly sophisticated C^4I systems and weapons platforms, at a deeper level, very little has changed. On the contrary, the technology is literally being "applied" into the current weapons platforms. As Cohen correctly points out,

> When the Clinton administration formulated its defense policy in 1993, it came up with the Bottom-Up Review, which provided for a force capable of fighting simultaneously two regional wars assumed to resemble the Gulf War of 1991. By structuring its analysis around enemy forces similar to those of Iraq in that year—armor-heavy, with a relatively large conventional but third-rate air force—it guaranteed a conservatism in military thought. . . . For this reason, among others, the revolution will take far longer to consummate.[142]

Combat arms officers support the technology because it provides information dominance "sensor to shooter"[143]—the

fused information passes almost simultaneously from the collection platforms to the weapons platforms, virtually bypassing the staff.

In this regard, Force XXI is helping the Army to leverage new technology to improve its current way of doing business. Force XXI and the C^4I systems which comprise ABCS focus on conventional regional aggressors. How the "digitized" Army expects to fight in the 21st century seems suspiciously like armored combat against the Warsaw Pact with new technology grafted on. As one AWE participant noted, "We don't do a good job of automating processes. We automate tasks. For example, we automate the task of producing an overlay, but not the process of producing a course of action. Consequently, machines are never used to the full extent of their capabilities."[144]

Therefore, in my view, ATCCS, its predecessors, and its successors belong to a "military technological revolution" in which technology is employed in an evolutionary manner, without causing major doctrinal or organizational change. We have witnessed the impact of information technology on warfare, but we have not yet seen the subsequent transformation of operations and organization. Without significant organizational or doctrinal change, these battlefield C^4I systems cannot embody the postulated RMA. As Mazarr warns in his most recent article about the RMA:

> This incrementalist notion of the RMA is ultimately self-defeating. It violates the common strategic principle that a period of rapid change is the time to think comprehensively rather than narrowly. It indefinitely postpones the day when the U.S. military will depart from deeply entrenched evolutionary doctrines and routines and embrace the truly revolutionary elements of the new era in warfare.[145]

The information revolution as conceived in the 4th Infantry Division exists—in Sullivan's own words—"to apply power" with the old weapons to a high-intensity predominantly-armored threat.

Given that ATCCS and ABCS do not embody the currently postulated RMA, perhaps it is valid to ask whether the RMA is actually capable of being accomplished—especially given the bureaucratic, political, and budgetary constraints in which the U.S. armed forces have to operate. I am not sure. In the current civil-military environment—where every "revolutionary" idea faces organizational pressures from within the government, military services, and their supporting contractor communities—an RMA which simultaneously synthesizes technological and doctrinal innovation is unlikely to occur. Perhaps military theorists have set the bar too high for service decisionmakers, program heads, and budget officers. Perhaps the RMA is an idealized construct rather than a feasible goal.

Nonetheless, to think about the information revolution in a comprehensive way would be to ask *with* what and *against* what should the Army be applying power? The Army still has the potential to capitalize on the postulated RMA, albeit not on its current developmental path. There are three possible ways in which the Army could embrace the new technology and radically alter its doctrine and core tasks.

First, the Army could seriously restructure its organization. The civilian analogue to this period was the large down-sizing and hierarchical flattening about 8 years after the information technology revolution in the corporate workplace. Similarly, TRADOC is conducting a "Joint Venture" force structure review, which could be the precursor to a parallel change in hierarchy. Several officers have postulated the way the post-Cold War Army should look; perhaps best known is LTC(P) Douglas MacGregor, who argues that the Army needs to move to smaller, more mobile organizations—similar to the combat commands used during World War II.[146] Blaker promulgates another vision, in which the total force structure would reflect the new RMA technologies. In Blaker's view, the active component, downsized and equipped with new capabilities,

would focus exclusively on the mid- to high-level intensity warfighting missions. The reserve component, which would retain most of today's heavy equipment and conventional capabilities, would take direct responsibility for all other missions, including peace operations.[147]

This debate parallels a similar force structure review in the 1950s, when the Army developed its pentomic army concept and eliminated battalion commands—and hence the functional purpose of lieutenant colonels. As with most structural changes, the pentomic army's effects were not immediately apparent; it was only later that the Army understood the organizational challenges created by officers having no troop contact between the ranks of major to colonel. Similarly, when corporate America down-sized middle management, its effects were also not immediately obvious. It was only after the organization was flattened that the implications were fully understood—eliminating middle management degraded organizational memory and effectively destroyed the mentoring and maturation process of leaders.

Second, the Army could seriously address the question of what future enemies will look like. Some RMA proponents argue that the future "battlefield" will be empty, with reconnaisance sensors and long-range precision strike weapons keeping opponents far apart. In this scenario close combatants would be rarely used, brought in at the end for the final "*coup de grace*." But I believe that future warfare will most likely be what we used to characterize as "low intensity conflict" against committed, manpower intensive, low-tech opponents. Such decentralized threats could increase if the United States pursues its current national security strategy of engagement and preventive defense. A highly decentralized threat, such as we faced in Somalia and Haiti, mitigates the capabilities of Force XXI technology.

> A future opponent, conversant with the lessons of the Gulf War and Vietnam, might choose to challenge MTR technology

by presenting an assymetrical low-tech strategy, perhaps one not energy based and therefore not vulnerable to most of our sensors. Such a strategy would minimize communications and electronic indicators so severely that there would be very little to "read." Such a response would effectively deny the ability to employ many offensive MTR capabilities . . . Our own love affair with decisive maneuver, precision strike and the ability to synchronize actions in time and space thus may not be relevant, possible or even desirable for all future opponents.[148]

As we pursue technology to advance our capabilities, we must be aware that there are limits to what technology can do, especially in preventive defense missions and peace operations.

Third, the Army could radically redefine its understanding of information warfare. This would require seriously addressing the capabilities that information technology *can* provide—from a fresh perspective. Some analysts argue the information revolution is far more likely to equalize power between the have and have-not countries than to concentrate it still further in the developed countries. Unlike nuclear weapons, commercial off-the-shelf technology is not prohibitively expensive to develop and maintain. Technology could disrupt in two ways—either through the information networks themselves or through physical attacks on key nodes. As the world's most advanced consumer and producer of information technology, the United States is also the most vulnerable.[149] On the one hand, small states or terrorist organizations could go after our C^2 infrastructure or the international currency markets by propagating computer viruses or hacking their way into networks. On the other hand, such organizations could plan physical attacks on key nodes. For example, the entire East Coast railroad network could be paralyzed by crippling the two computers which control it.[150]

This third line of reasoning presents another danger as well. Simply put, other nations with a clearer strategic purpose and less sunk capital at risk could become leaders

in the current RMA. Despite notable progress, when we look back, we may see the 1980-90s as a period of unrealized potential, roughly comparable to the 1920-30s, when cavalry and infantry stubbornly resisted the internal combustion engine for motorized warfare. In this regard, the currently postulated RMA is eerily similar to the British interwar mechanization experience.

> Anyone looking at European military thinking between the world wars would have assumed that the British or French would have been the masters of the new forms of warfare. The conceptual writings of people like Charles DeGaulle, B. H. Liddell Hart, and J. F. C. Fuller outshone those of their German counterparts. But the Germans, unlike the British, empowered their visionaries and allowed them to restructure doctrine, tactics, training, and all the other elements of military art.[151]

The U.S. Army is dangerously close to the same trap. Another country might capitalize on an RMA first because it could start with a clean slate and think strategically, while the United States will be updating an outdated system incrementally.

With this comparison in mind, I argue that military innovation is caused by a challenge to the military's existing conventional hierarchy. This challenge can originate from many sources—defeat in battle, extreme budget cuts, organizational irrelevance in light of new technology. Such a fundamental challenge to the hierarchy is necessary to create the conditions in which the organization will willingly alter its core tasks—and even then, it alters these tasks only because it has no other choice. After World War I, in victorious Britain the military hierarchy remained in charge and thus used technology to update its existing system of waging war. In contrast, the defeated German military had its hierarchy threatened and thus was willing to develop a new system.

Even ATCCS—while not an innovation as defined in this paper—had potential to be an innovative program: first as

Sigma Star under Starry and then as ABCS under Sullivan. In both periods, the hierarchy was significantly challenged, which caused a shift in the innovative balance of power between the user and developmental/testing communities. Under Starry, there was a renewed awareness that the smaller, professional Army was not capable of successfully defending against the larger Soviet threat. This challenge gave rise to Sigma Star and AirLand Battle. Under Sullivan, the end of the Cold War effectively eliminated the external enemy and threatened to make the Army irrelevant. This challenge gave rise to ABCS and Force XXI. In neither case, however, was the hierarchy so challenged as to force the organization to embrace a new system of waging war. I argue that without this factor, military innovation does not occur.

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